GENERAL NOTES.

GEOLOGY AND PALÆONTOLOGY.

ON THE THEORY OF GLACIAL MOTION.[1]—As glaciers deport themselves like rivers, in that they are constantly flowing, with greater velocity at centre than at margins, above than below, form pools and rapids, and conform themselves to channels, Prof. Forbes was led to propose the theory that: "A glacier is an imperfect fluid or viscous body which is urged down slopes of a certain inclination by mutual pressure of its parts."[2] He explained the veined structure of glaciers as being due to differential movement of its parts.

Against this view, it was urged that ice is a brittle solid, which in the laboratory cannot be moulded as a semi-fluid, or even in nature, when in passing over a change of declivity of even 4½ degrees, it becomes ruptured. Consequently, Prof. Tyndall applied Faraday's "Law of Regelation,"[3] that ice when broken and moistened, re-united and could be moulded into any form by repeated crushing and pressure, and proposed the "Fracture and Regelation theory." He explained the veined structure of glaciers as being analogous to the slaty cleavage of certain rocks—the result of transverse pressure.

Canon Moseley[4] calculated that the resistance of ice to descent is thirty-four times gravitation, and, therefore, fracture and gravitation could not be maintained. He likened the motion to the creeping of a leaden roof, owing to the expansion and contraction from change of temperature, which expansion Dr. Croll[5] modified in assuming the transmission of heat from molecule to molecule with successive liquefaction and solidification of the glacial waters.

Malleability, plasticity and viscosity are different degrees of the same property. Prof. Heim[6] distinguishes between these last two semi-fluid forms. In plastic bodies, the internal cohesion is less than internal resistance, and, therefore, under pressure these will flow, but under tension they are not drawn out, but are brittle. In viscous bodies, the internal cohesion is greater than internal resistance, and, therefore, they will not only flow under pressure, but in tension they are drawn out before rupture. He concludes that glaciers are plastic bodies, and explains the veined structure as being due to partial liquefaction under compression in passing through narrow

[1] Read before the Royal Society of Canada May, 1887, and before the A. A. A. S., Aug., 1887. Printed from advance sheets of Trans. Roy. Soc., Canada, for 1887.

[2] Travels in the Alps, 1843.

[3] Forms of Water.

[4] Proc. Royal Society, 1869.

[5] Climate and Time.

[6] Handbuch der Gletscherkunde von Dr. Albert Heim, Stuttgart, 1885.

channels, as it had been discovered that ice can be melted by pressure (Thomson). He attributes the motion to plastic flow under gravity, rupture, partial regelation, and a sliding motion (which is slight).

From observations in the Alps, and especially in Norway, my conclusions are that the motion, in the main, is the result of gravity on a semi-fluid body, wherein there is viscosity as well as plasticity, as defined by Prof. Heim; the motion, of course, being greatly modified by heat. My conclusions are based upon:—(1) The flow of the glacier, not merely in conformity to the channel, but about loose stones, which cause the lower surfaces of the glacier to be grooved (see fig. 1, in my Glacier Erosion in Norway[1]) without any lateral ridges being produced from the ice that filled what are now its channels, such being moulded into the mass (this is *plasticity*). (2) A tongue of ice (see fig. 3) pushing against a boulder, was bent back without rupture on either side of the hanging plate,—the ice on one side being in tension and on the other in compression (here is viscosity). (3) A large rounded boulder (see fig. 2), held in the side of a moving glacier, where the rounded ice wall rose about thirty feet above the stone, which was being rolled along as the ice moulded around it, had just been crushed by weight. The glacier rose along its winding course to the snow fields, 1,500 to 2,000 feet above the stone. Consequently the crushing weight upon the granitoid boulder must have been derived from the vertical component of the momentum of descent of the whole mass, which could be transmitted thus only through a semi-fluid body. (4) The flow of the upper layers of ice over the lower was seen when the glacier was impeded by a barrier (see fig. 4).

The experiments of Herr Plaff[2] show that a solid body can be pressed into ice at a temperature about freezing point as rapidly as glaciers ordinarily move; whilst at a temperature a little above, the motion is greatly accelerated, but if below 0° C, the plasticity of the ice diminishes rapidly to almost zero. However, as shown by the sub-glacial streams in winter, the temperature of the inferior surface glacier is not below freezing point.

The effects of increased summer sunlight, as well as direct heat, as shown by the experiments of Rev. A. Irving,[3] in which he transmitted both sunlight and heat waves through ice, is to accelerate the movement as the former is converted into heat undulations, and radiated against the lower part of the glacier from the adjacent rocks, thus increasing the fluidity of the ice and flow of the glacier, owing to increase of temperature.

The temperature of the lower surface of the glacier is also slightly increased by the radiation of the internal heat of the earth, yet

[1] See American Naturalist, March, 1888.
[2] Nature, Aug. 19th, 1875.
[3] Q. J. G. S., Feb., 1883.

this is very slight, as the amount radiated per annum is only enough to melt 6.5 millimetres of ice.[1]

Although glaciers do not conform to all the inequalities of their beds, and at the ice-falls and elsewhere became fractured, and subsequently re-united, whether by heat regulation or plastic flow, the fluidity theory is the most acceptable explanation of the motion of glaciers, even when the angle of descent is reduced to almost zero, and modern observations only supplement the reasons upon which Prof. Forbes proposed his theory more than forty years ago.—*Prof. J. W. Spencer.*

A CRETACEOUS BIRD-TRACK.—Professor F. H. Snow has recently, in the *Trans. Kansas Acad. Sciences*, described a fossil bird-track discovered in the Dakota sandstone, in Ellsworth county, Kansas. The impression appears to have been made by the left foot of some bird with an elevated hind-toe just reaching the ground. The ball of the foot is deeply impressed and the posterior toe has made an unmistakable imprint, proving the avian character of the footprint. It measures two inches from anterior middle claw to claw of posterior toe. This discovery considerably lowers the geological horizon of Kansas birds, since nearly all the material for Marsh's *Toothed Birds* was obtained from the Niobrara, the highest group of the Cretaceous represented in Kansas. Below this lies the Benton, followed by the Dakota, resting unconformably on the Permo-Carboniferous rocks.

Professor Snow continues thus: "The wonderful luxuriance of the land vegetation of the Dakota, and its marvellous similarity to the Dicotyledonous forest-growths of the warm-temperate climes of the present day, have rendered these sandstone beds a most fascinating field of investigation for both Paleo-botanists and Neo-botanists. The finely-developed and perfectly-preserved foliage of oaks, willows, poplars, laurels, sarsaparillas, magnolias, sassafras and other kindred forms belonging to genera now long since extinct have hitherto suggested a beauty of landscape whose perfection was only marred by the apparent scarcity of animal forms. . . . . Our bird-track supplies the missing element of graceful ærial forms. From the size of the footprint, it may be safely inferred that the bird which left it was somewhat larger than a pigeon. It was probably a bird with teeth," "with habits similar to those of the modern tern."

THE AFFINITIES OF MIOLANIA.—G. A. Boulenger reports (P Z. Soc. Lond., June 23, 1887) that the large Plistocene Chelonian Miolania, which was regarded by Huxley as probably belonging to the group Cryptodira, and closely allied to Chelydra, Macroclemmys and Platysternum, is, in fact, like all the recent tortoises of

[1] Elie de Beaumont, Thompson Woodward and others, give range from five to eight millimetres. University of Missouri, May 1st, 1887.

Australia, a member of the Pleurodira. Mr. Boulenger bases his opinion upon the examination of a nearly perfect skull with the two cervical vertebræ attached. The structure of the alveolar surface of the skull indicates an herbivorous animal; the ungual phalanges and the curious sheathed tail a terrestrial one. This sheathed tail, with its opisthocœlous centra, is unique among the Pleurodira, and points to a distinct family. The ilium shows a surface for attachment to a sacral.

The Pleurodiran characters are—the broad pterygoids, with outer palatal borders forming wing-like expansions; the tympanic cavity completely surrounded by the bony roof; the articulation of the mandible by a condyle fitting into an articular concavity of the quadrate, and the form of the cervical vertebræ.

Geology of the Solomon Islands.—Mr. H. B. Guppy has recently published a work upon the Solomon Islands, divided equally between the volcanic and calcareous members of the group. The volcanic islands fall into two classes—the first comparatively modern and mainly composed of little-altered augite sandstones, andesitic pitchstones, tuffe and agglomerates; the second, composed partly of the above rocks, but in part of much more ancient crystalline masses, consisting chiefly of altered dolerites, quartz-diorites and porphyies and serpentines.

The coral rocks of the Solomon Islands are divided by Mr. Guppy into: (1) True coral limestones; (2) Coral limestones which have the composition of the coral muds or sands now forming near coral reefs; (3) Rocks having the composition of volcanic mud and pteropod ooze; (4) Foraminiferal limestones; (5) Rock resembling a consolidated deep-sea clay (red clay). The two last classes were evidently deposited at depths of not much less than two thousand fathoms in an ocean far from continental land; and this is the first proof of their existence above sea-level.

Mr. Guppy draws the following inferences: (1) That these upraised reef-masses, whether atoll, barrier reef or fringing reef, were formed in a region of elevation; (2) That such upraised reefs are of moderate thickness, their vertical measurement not exceeding the usual limit of the reef-coral zone; (3) That these upraised reef-masses, in the majority of islands, rest on a partially consolidated deposit which possesses the characters of the "volcanic muds" that were found, during the Challenger Expedition, to be at present forming around volcanic islands; (4) That this deposit envelopes anciently-submerged volcanic peats. The author says: "I never found one (raised reef) that exhibited a greater thickness of coral limestone than one hundred and fifty feet, or, at the outside, two hundred feet."

Geological Survey of Arkansas.—From a small pamphlet —Annual Report of the State Geologist of Arkansas for 1887—

we learn the Survey began work June 24th, with a corps of a director, three paid and seven volunteer assistants. The work done the first year has been the triangulation of the immediate vicinity of Little Rock; the examination of localities reported to yield gold and silver, especially in Garland and Montgomery counties; a reconnoissance in the central part of the State; tracing the limits of the Cretaceous in the southwestern part of the State. The bill providing for the survey makes appropriations for its continuance for two years.

GEOLOGICAL NEWS.—PALÆOZOIC.—Dr. J. V. Deichmüller describes two new species of the genus Etoblattina Scudder obtained at Grügelborg, near St. Wendel (Rhenish Prussia), not far from a spot where fish, insect and plant remains have been previously found. They are described under the titles of *E. ornatissima* and *E. rollei.*

CRETACEOUS.—Mr. A. S. Woodward concludes, after examination of the five series of examples in the British Museum, that *Cyclobatis oligodactylus,* the so-called "Torpedo," from the Cretaceous of Mount Lebanon (Syria), is really a member of the sting-ray family (Trygonidæ). Among his reasons are: The pectoral fins are uninterruptedly continued to the end of the snout, and were thus, probably, confluent in front—a condition never met with among the Torpedinidæ; the pelvic arch is placed far forward; there are no traces of median fins, and the skin is armed with spinous tubercles.

FROM an examination of specimens in the Cambridge and Brighton Museums (Eng.), Mr. A. S. Woodward concludes that the puzzling genus Ptychodus, which was by Agassiz and Owen referred to the Cestraciontidæ, is doubtless a true ray, though possibly belonging to an extinct family.

MR. J. W. DAVIS (*Trans. Roy. Dublin Soc.,* 1887) describes the fossil fishes of the chalk of Mount Lebanon. In this important paper no less than ten genera and sixty-six species are introduced to scientific knowledge. Among these are two genera and twelve species of Selachians, of which group nine genera and sixteen species occur; two new species of the Pycnodont genus Palæobalistum, and two forms having some affinity with Amia; several new Berycidæ; two species of Platax; a small flying-fish; a Fistularid, and several Salmonidæ and Clupeidæ; also, *Xenophilis carinatus,* six species of Rhinellus and two species of Anguilla, the first Mesozoic eels yet known,—are among the Teleosteans.